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Height Growth Characteristics of Siberian Elm in Central Great Plains Windbreaks

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Curves of tree height in relation to age have both practical and research value in Plains forestry:

1. Height-age curves are necessary to remove tree age as a variable in classification of soils for trees.
2. A knowledge of the shape of height-age curves can assist in classification and correlation of soil characteristics in terms of tree growth.
3. Curves are important to aid the forester in management decisions such as tree-row removal, thinning, and desirability of certain species combinations.
4. They are important for determining maximum effective windbreak heights, a factor used to determine the proper spacing intervals between windbreaks.

In 1959, a study was initiated to obtain height-age data for several species of Plains windbreak trees. Curves for Austrian and ponderosa pine have been reported.^{2,3} This paper reports growth curves for Siberian elm, *Ulmus pumila* L., an introduced species used extensively in the Plains region. It is often called by the misnomer, Chinese elm.

Procedure

Ten dominant Siberian elm trees were measured in each of 15 field windbreaks planted by the Prairie States Forestry Project during the period 1937 to 1941. The windbreaks represented average tree-growing conditions for each area shown in fig. 1. A general description of the soils in each area is given in table 1. Water tables were beyond the

reach of tree roots on all sites except in Morrill County, Nebraska, in the western Platte River Valley, and possibly in the sandy loams of Rice County, Kansas. The Morrill County windbreaks were also irrigated.

Height at different ages was determined by stem analysis on 10 dominant and codominant trees in each windbreak sampled. An attempt was made to select trees least influenced by adjacent rows of other tree species. The height and age data were smoothed by regression methods, and site index curves were constructed.

Results and Discussion

Growth Curves in Nebraska and Kansas

While height-age curves for ponderosa pine were similar on different soils or geographic areas in Nebraska,² the curves for Siberian

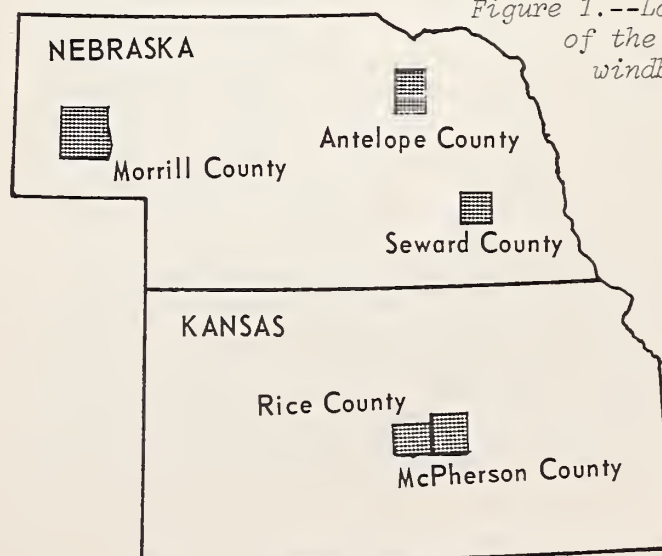


Figure 1.--Location of the sample windbreaks.

Table 1. --General description of the soils in sampling areas

State and County	Sample trees	Soil description
	Number	
Nebraska:		
Antelope	30	Sandy loams, on level topography, developed from Peorian loess. Marshall-Monoma-Ida soil association.
Seward	50	Silty clay loams, on level topography with silty clay subsoil, developed on Peorian loess. Crete-Butler-Fillmore soil association.
Morrill	30	Fine sandy loams on level topography in Platte River Valley, developed from loess and alluvium. Tripp-Bridgeport-Bayard soil association.
Kansas:		
McPherson	20	Silty clay and silty clay loams on level topography with silty clay subsoil, developed on Peorian loess, Crete-Goessel soil association.
Rice	20	Sandy loams on level topography formed on outwash sands, Pratt-Abion-Derby soil association.

elm were different. Mean height-age curves for Siberian elms on the silty clay loam soils of Seward County were starting to flatten out at age 25, much earlier than the curves for trees on the sandy loam soils of Antelope and Morrill Counties (fig. 2). Although height growth was initially greater on the heavy-textured soils, this advantage was lost after 15 to 20 years. Rate of height growth on the heavy-textured soils exceeded growth on the sandy soils only for the first 10 years; thereafter growth rate was higher on sandy soils. This substantiates the observations of other investigators who have noted that tree height growth on light-textured (sandy) soils is generally greater than on heavy-textured soils.⁴⁵

Height growth curves for the sandy loam soils of Antelope and Morrill Counties, Nebraska, were nearly alike. The soils in both areas are generally loam and sandy loam topsoils with loam, sandy loam, or silt loam subsoils. Although average annual precipitation in Morrill County is about 8 inches less than in Antelope County, irrigation of windbreaks in the western areas apparently equalizes growing conditions insofar as available moisture is concerned.

Height-age curves within the Seward County, Nebraska, sampling area were of two distinct forms (fig. 2). Soils in this area of the Loess Plains form a series association with tendency to develop claypans in depression areas. Growth of trees sampled on these claypan soils, known as Fillmore, had distinctly different curves than the trees on other loess soils. Although early height growth on these claypan soils was as rapid as on other loess-derived soils, the rate of height growth decreased rapidly after the first 5 years.

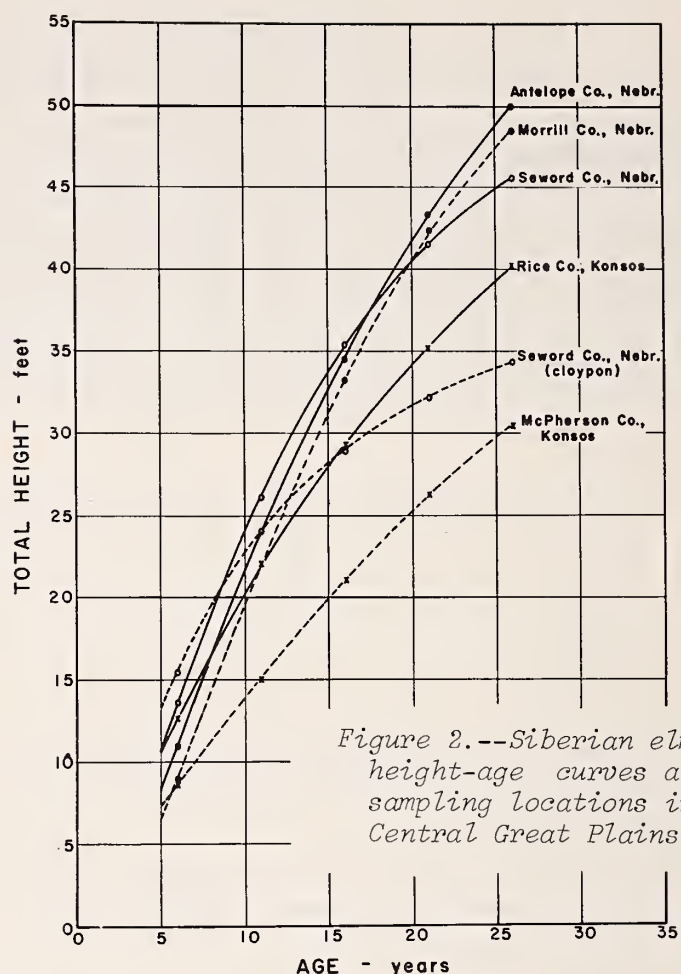


Figure 2.--Siberian elm height-age curves at sampling locations in Central Great Plains.

The rate of height growth at 20 to 25 years on the claypan soils was reduced to 0.5 foot per year (fig. 3), which indicates that the trees were approaching maximum heights on these soils. The heavy claypan undoubtedly limits root penetration and distribution, and this becomes more critical as the trees grow larger. Trees growing on the silty clay loam soils with no claypan averaged almost twice as tall at 20 to 25 years of age as those on the claypan soils. Height growth declined at about the same rate after 15 years of age on the non-claypan soils and the sandy loam soils in Antelope and Morrill Counties.

The downward slopes of periodic annual height growth in figure 3 are very similar for all Nebraska locations. This indicates that tree vigor as expressed by height growth is declining at about the same rate on all soils and locations sampled in Nebraska. Extrapolation of these height growth rates indicates that Siberian elm will essentially reach maximum height at 32 to 36 years of age on these sites in Nebraska. Although such extrapolation can be hazardous, the general performance of older Siberian elms reaching 35 years of age, seems to bear out this prediction.

Height growth of Siberian elm was much less in Kansas windbreaks than in Nebraska (fig. 2). On the sandy loam Pratt-like soils in Rice County, Kansas, total height was 8 to 10 feet less at age 25 than on the sandy loam soils in Nebraska. The rate of height growth for the first 5 years on these sandy soils was somewhat faster in Kansas, however.

Although the silty clay soils in Kansas were loess derived and similar to the silty clay loam soils in Nebraska, the rate of height growth for the first 20 years in Kansas was much less than in Nebraska. At 20 to 25 years of age, however, the growth rates on these heavy-textured soils in Kansas and Nebraska were identical (fig. 3). Possibly differences in climate or in the genetic constitution of Siberian elm influenced height growth more than the apparently similar soils.

While Siberian elm on the sandy loam soils in Rice County grew taller than on the heavy-textured silty clay soils in McPherson County, the curves for both soils were similar. In this case the similar climatic conditions of the geographic areas possibly influenced height growth more than did the differences in soil types.

Site Index

The height-age curves of Siberian elm vary according to soils and geographic location. Site index curves were therefore constructed for several combinations of location and soil (fig. 4). Since these windbreaks are relatively young, ranging from 20 to 25 years old, site index was determined on a base of 15 years.

The site index curves based on measurements in Seward County, Nebraska, (fig. 4A) should be reasonably applicable throughout the Nebraska Loess Plains area. Additional unpublished data indicate that most of the Loess Plains in Nebraska will have site indices for Siberian elm ranging from 24 to 30 feet at base age 15. In general, the Hastings soil series in the western Loess Plains have site indices from 22 to 27 feet. The Crete series of the eastern Loess Plains have site indices from 27 to 33 feet. Local areas where runoff water concentrates may have indices above 33 feet, whereas very eroded soils may have indices below 22 feet.

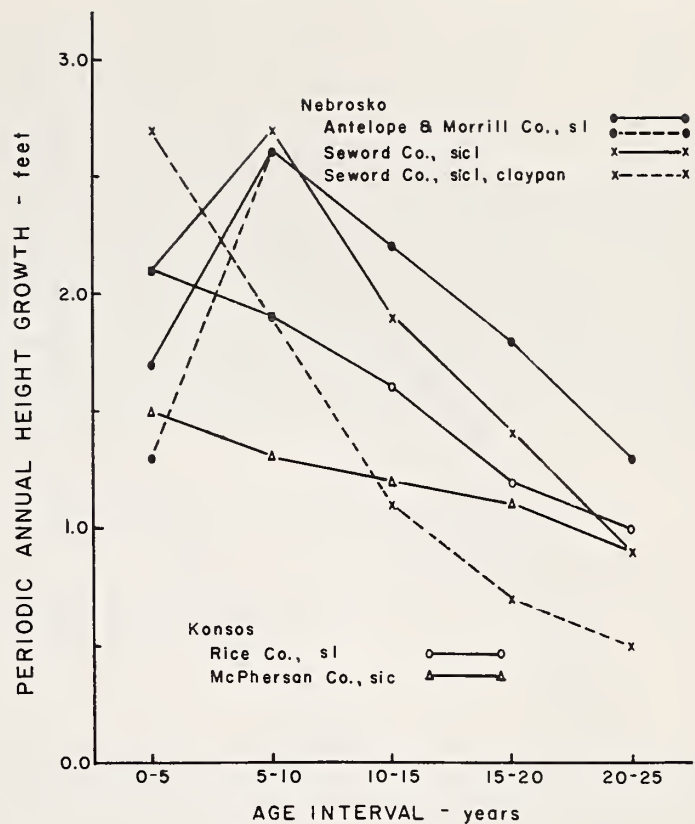


Figure 3.--Periodic annual height growth of Siberian elm at locations sampled in the Central Great Plains. (sl = sandy loam; sic - silty clay; sicl - silty clay loam).

Site index for Siberian elm on the Fillmore claypan series in the Loess Plains averages approximately 28 feet (fig. 4A), but indices may be lower or higher depending on local conditions. More information is needed for these soils to determine causes of slow height growth after trees reach 15 to 20 years of age. Root growth and distribution are very likely restricted by the shallow A horizon and physical characteristics of the claypan.

Since height-age curves for Siberian elms on the sandy loam soils of Antelope and Morrill Counties, Nebraska, were very similar, one set of site index curves can be used for both areas (fig. 4C). Although curve form is probably reliable enough for the locations sampled, other soils in these areas--for instance, soils without loess subsoil in the Antelope County area--may have slightly different curve shapes.

Although soils of the windbreaks sampled in Kansas were greatly different in texture, the height-age curves for Siberian elm were very similar in form. Therefore site index curves for Kansas include both the silty clay and sandy loam soils (fig. 4D).

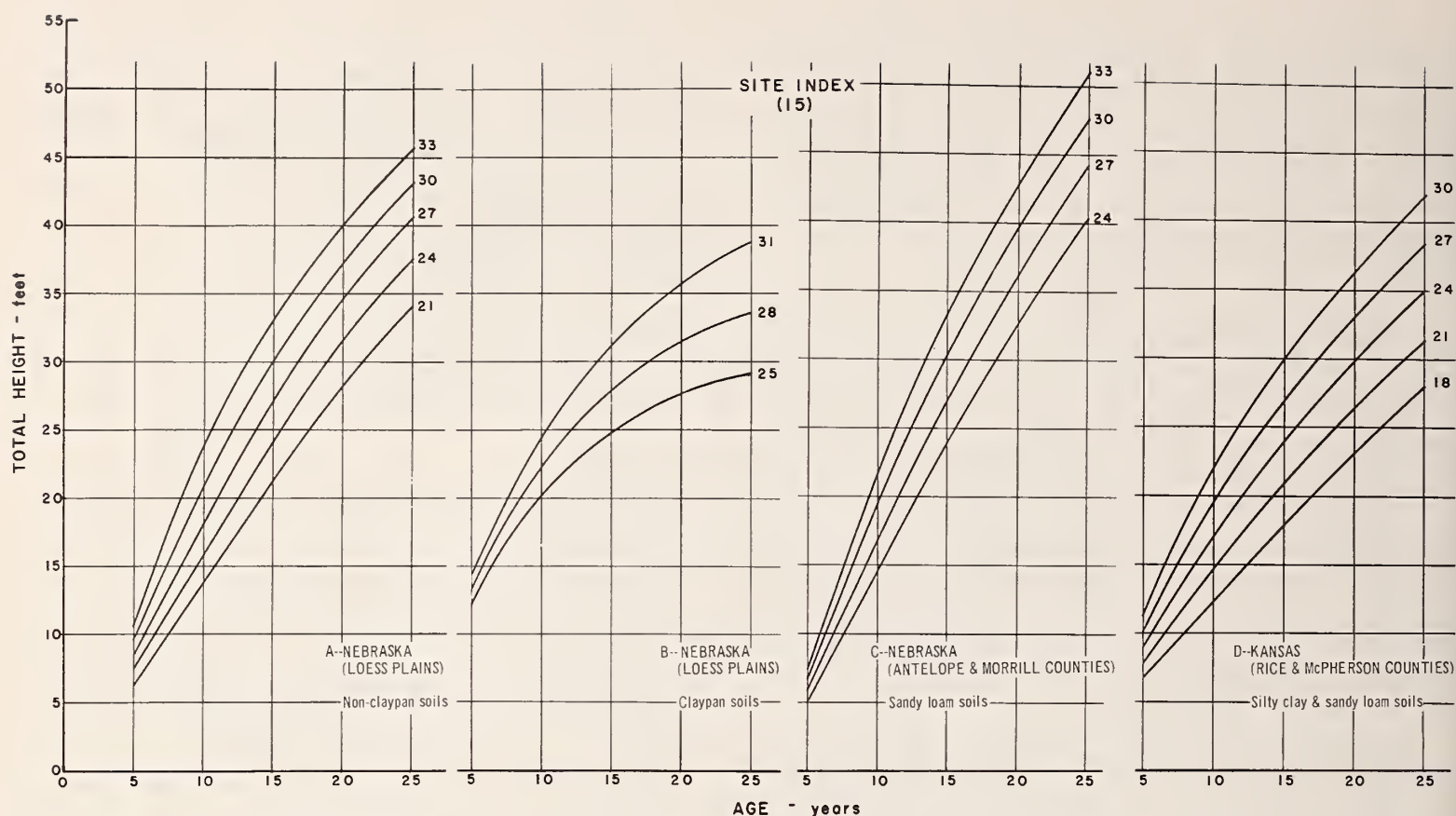


Figure 4.--Site index curves for Siberian elm in windbreaks sampled in Kansas and Nebraska, 1959.

Summary

Height-age data for Siberian elm were collected by stem analysis techniques from different general soil types and geographical areas of Nebraska and Kansas. Differences found in height-age curves depended on general soil characteristics and the geographic area sampled.

Siberian elm growing on silty clay loams derived from loess in Nebraska grew faster immediately after planting than trees growing on lighter textured soils, but after 10 to 15 years the rate of height growth on the sandy loam soils was superior. Siberian elm on heavy claypan soils grew rapidly at first, then slowed to only 0.5 foot per year by ages 20-25.

Height-age curves were similar in shape for trees on both heavy- and light-textured

soils in Kansas, but the curves were different from those for trees in Nebraska on generally similar soils.

Extrapolation of height-growth rates indicates that Siberian elm may essentially stop growing in height at 32 to 36 years of age in Nebraska on all soils and at different locations. In Kansas, height growth will be maintained for a slightly longer period of years.

Site index curves are presented for the soils and geographic locations that have different height-age curves. Because of limited sampling, it is not known how well the curves represent the tree populations in each area, but additional data from the Loess Plains of Nebraska substantiate the site index curves for that area. Additional sampling will be necessary to determine how widely they can be applied.

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²Sander, D. H. Growth curves for ponderosa pine in Nebraska windbreaks. U. S. Forest Serv., Rocky Mountain Forest and Range Expt. Sta. Res. Note 82, 3 pp., illus. 1962.

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⁴Albertson, F. W., and Weaver, J. E. Injury and death or recovery of trees in prairie climate. Ecol. Monog. 15: 393-433, illus. 1945.

⁵Hayes, F. A., and Stoeckeler, J. H. Possibilities of shelterbelt planting in the plains region. Sect. 12. Soil and forest relationships of the shelterbelt zone. U. S. Forest Serv., Lake States Forest Expt. Sta. Special Pub., pp. 111-153, illus. 1935.